BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's Rules	)	ET Docket 98-153
Regarding Ultra-Wideband Transmission Systems	)	

To: The Commission

COMMENTS OF THE U.S. GPS INDUSTRY COUNCIL

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The U.S. GPS Industry Council ("the Council"), by its attorneys and pursuant to Section 1.415 of the Commission's Rules, 47 C.F.R. § 1.415, hereby comments upon the Commission's Notice of Proposed Rule Making ("*NPRM*") in the above-referenced docket.[1]

I. SUMMARY

The *NPRM* continues the Commission's examination of the myriad technical and policy issues surrounding the advent of devices employing ultra-wideband ("UWB") technology, and is, by far, the most comprehensive agency undertaking on the subject to date, in terms both of its scope and its potential impact on existing and future users of the radio spectrum.[2] The Commission should use the opportunity of this proceeding to define the technical bases for determining whether or not UWB devices can be authorized, and if so, how to do so in a manner which is transparent and predictable to industry while protecting such critical public interests as public safety and national

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1 *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, Notice of Proposed Rule Making, FCC 00-163, slip op. (rel. May 11, 2000) ("*NPRM*").

2 The Commission, either directly or by delegated authority, has taken several preliminary steps regarding UWB technology applications. *See Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, FCC 98-208 (ET Docket No. 98-153) (Notice of Inquiry) (rel. September 21, 1998) ("*UWB NOI*"); *The Office of Engineering and Technology Grants Waivers for Ultra-Wide Band Technologies*, Public Notice, DA 99-1340 (rel. July 8, 1999) (reporting grants of waivers of certain Part 15 rules to Time Domain Corporation, U.S. Radar, Inc., and Zircon Corporation to allow the limited marketing of UWB devices subject to certain conditions) (collectively, "*UWB Waivers*"). On July 14, 2000, the Commission denied reconsideration and review of the *UWB Waivers*. *See U.S. GPS Industry Council, American Airlines and United Airlines, Consolidated Petition for Reconsideration of Waivers Issued under Delegated Authority by the Chief, Office of Engineering and Technology*, FCC 00-29 (rel. July 14, 2000) ("*UWB Waiver Recon. Order*").

security which rely on the Global Positioning System ("GPS"). The task of the Commission is to find a "way forward" based on sound science and prudent spectrum and risk management.

UWB technology, at its lowest common denominator, supports a class of uses of spectrum that varies significantly from the typical radiofrequency emitter. Instead of occupying a discrete portion of the spectrum, a UWB device operates across vast expanses of spectrum. Whether UWB should operate across the heavily used lower end of the radiofrequency spectrum that is occupied by thousands of stations in dozens of services is the core issue. Even though operation would ostensibly be on a non-interfering basis ("NIB") with respect to existing primary and secondary users of the spectrum, the strong transient pulse and wideband features of UWB do not allow for the use of currently established methods of monitoring the source of the interference, and therefore prevent the interfering behavior from being effectively addressed. When frequency bands across which UWB devices could operate are used for safety-of-life applications or are bands where operation of NIB emitters are forbidden under the Part 15 of the Commission's Rules, an even more fundamental problem occurs. The net effect of numerous UWB devices in any safety-of-life band will have the effect of raising the noise floor. This, in turn, compromises the safety functions of the victim devices.

The implications of UWB go far beyond the applications now discussed by advocates in that consideration is being given to a fundamental restructuring of the spectrum management approach used by the United States for almost 75 years and throughout the current information revolution. UWB transmission systems are best characterized by time domain measurements (*i.e.*, such systems transmit signals that are extremely short or discontinuous – as opposed to continuous – in time, with the temporal shortness resulting in energy distributed in wide radiofrequency bandwidths). This use contrasts with the existing spectrum management framework for continuous signals, whereby specific frequency blocks are allocated to particular radio services and frequency assignments are then made to users within those services.[3] Modern digital radios permit the efficient use of these frequency blocks and are limited in their effective use by the thermal noise floor and unintended signals in the band. Any inclusion of additional transmissions in these bands will decrease the value and reliability of existing services.[4]

Establishment of the infrastructure needed to manage the overlay of time domain signals, over conventional frequency domain signals, represents a fundamental paradigm shift. Historically, administrations have managed the spectrum by allocating the right to transmit synchronous signals at a specified power level as a function of frequency. This was done to manage interference among different services and technologies. Correspondingly, to manage discontinuous time domain waveforms, administrations now need to figure out how to allocate and manage peak power on a nanosecond basis.

The proposed rationale for this overlay is that a UWB communications system is necessarily broadband and operates below the threshold of conventional receivers providing efficient shared use of the spectrum. To operate below the noise floor requires UWB performance penalties (e.g., reduction signal to noise). The sum of these penalties increases the UWB communication receivers' vulnerability to interference from conventional transmitters, thereby decreasing their commercial operational reliability. The potential commercial utility of UWB communications systems will require higher data rates which will lead to higher transmit power. Higher UWB transmit power will lead to greater levels of interference to conventional receivers. Consequently, the overlay of

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3 Specifically, most of the UWB technology under consideration is pulsed communication. To effectively manage pulsed communication, an infrastructure to manage the time domain aspects of the radio spectrum must be established that allows for the allocation and monitoring of peak power per hundreds of picosecond sampling intervals.

4 Ironically, UWB transmission signals are similar to the early, unregulated uses of radio in the beginning of the twentieth century, following the discovery that radio waves could be used for communications over large distances. The resulting cacophony threatened the development and utility of the new technology, and led Congress to establish the Federal Radio Commission, precursor to the Federal Communications Commission, in 1927. The establishment of an agency to regulate the use of radio waves marked the shift in radio use from a time domain "regime" characterized by wideband, pulsed applications to the frequency domain infrastructure that has now been in place for nearly three quarters of a century.

time domain discontinuous, pulse communications over conventional, synchronous systems is a zero-sum tradeoff in interference tolerance, not a revolutionary spectrum sharing approach that maximizes efficient use of the spectrum.

Juxtaposition of the two paradigms, one well characterized, and one marginally understood, is a prescription for chaos. The preponderance of the National Information Infrastructure ("NII") is currently situated in the frequency spectrum below 3 GHz. Increasing the noise floor in this area of the spectrum will potentially have a very large destabilizing effect on the economic engine driven by information technology. Turning this area of the spectrum into a giant citizens radio band will not foster productive competition.

In these Comments, the Council begins to address the numerous substantial technical and policy issues facing the Commission and the millions of users of hundreds of radio services across the spectrum. UWB transmission signals have a broad potential victim list (from broadcast television receivers, to cellular and satellite service customers, to the "last mile" universal access and broadband internet connectivity, to the vast user communities that rely on signals from the satellites of the GPS for navigation and timing information in literally hundreds of applications). The Commission will need to take great care and exhibit extraordinary wisdom if it is to determine with safety and certainty just which, if any, applications of UWB technology can be permitted and under what conditions.

In this last regard, comprehensive testing will be required – well beyond the initial efforts now underway on an accelerated timetable that are only attempting to characterize ground or rubble penetrating radar.[5] Comprehensive testing to prove the non-interfering basis of UWB could well be endless if it is not premised on a basic understanding of the physical sciences underlying regulatory

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5 *See, e.g.*, Ming Luo *et al.*, Stanford University, Potential Interference to GPS from UWB Transmitters: Test Plan – Version 4.5, Phase I: Accuracy Test for Aviation Receivers and Reacquisition Time Test for Land Receivers, at 2 (May 1, 2000).

actions that juxtapose time domain devices with frequency domain devices. A physical science evaluation of the interaction between time domain devices and frequency domain devices will point to potential areas of worrisome interference. Testing can then be directed towards establishing a rational regulatory framework to accommodating two fundamentally different approaches to the use of the frequency spectrum without marketplace disruption.

The Council has struggled mightily with these issues in an attempt to identify examples of situations where UWB transmission signals may be employed without exposing users of GPS technology to the specter of harmful interference. The Council is not oblivious to the UWB proponents' strident demands for Commission action to approve at least some uses of UWB technology, and, after thorough consideration, has satisfied itself that there may well be some limited circumstances where properly-conditioned use of UWB technology could be compatible with GPS.

These Comments are devoted to an exploration of the regulatory, policy, and technical issues associated with UWB that are raised in the *NPRM.* The Council appreciates the opportunity to contribute to this process, and expresses its unwavering belief that the Commission must ensure that any action it takes in this or any offshoot proceeding does not run afoul of the stated commitment the Commission makes to precluding UWB transmission signals from interfering with GPS receivers in the 1160-1215 MHz, 1215-1240 MHz, and 1559-1605 MHz bands.[6]

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[6] *See NPRM*, FCC 00-163, slip op. at 11 (¶ 24), 13 (¶ 29).

II. INTRODUCTION

A. Statement Of Interest

The Council is a non-profit 501(c)(6) industry trade association whose mission is to act as a GPS information resource to the Government, the media, and the public. Its purpose is to promote sound policies for the development of commercial markets in civilian applications, while preserving the military advantages of GPS. Current membership includes the principal U.S. manufacturers of GPS equipment — *e.g.*, Boeing, Honeywell, Magellan/Orbital Sciences, Rockwell International, and Trimble.

B. Overview Of The GPS System And Its Importance To The U.S. Economy

The Global Positioning System is a satellite-based global navigation system originally developed for dual use by the U.S. Government to enhance the effectiveness of U.S. military forces and to improve the safety of civil navigation. The orbits of the GPS satellites have been designed so that multiple satellites are visible from any given spot on the earth's surface all the time. Each satellite transmits a time-coded signal. A GPS receiver then uses data from multiple satellites to rapidly calculate the worldwide location, altitude, and velocity of the vehicle or aircraft or person carrying the mobile receiver – within a range of from mere millimeters to a few meters. Position data and navigation are thus enabled by global access to precision time signals broadcast from space. These time signals may themselves be used to synchronize widely distributed networks such as wireless communications and the Internet.

GPS applications differ with respect to how many satellites are required. On the sparse side, a few time transfer applications only require one satellite in view. However, most safety critical applications cannot afford to lose any satellites to an unanticipated new mechanism such as UWB interference – they rely on the full set to cover other contingencies.[7] While in theory, a minimum of

[7] For example, the police car or ambulance, navigating the city streets to find a citizen in need, relies on extra satellites to cover the effects of building blockage or attenuation by foliage. Aircraft applications require extra satellites in case any satellite is lost due to a failure of the on-orbit hardware.

four satellites in view can result in a three-dimensional position determination (i.e., calculated results for x, y, z spatially coordinates and time coordinate t), in actual practice, GPS receivers seek to acquire anywhere from 6 to 12 satellites to find those with the best spatial locations at any particular time.[8]

The GPS operates in the "L1" band at 1559-1610 MHz and the "L2" band at 1215-1240 MHz. At the 2000 World Radiocommunication Conference, the "L5" band at 1164-1215 MHz band was established. These bands have been allocated internationally for the Global Navigation Satellite Service ("GNSS"), including GPS, the Russian Federation's Global Navigation Satellite System ("GLONASS"), and the European Galileo initiative, and will be used for new service enhancements in their evolution. Further, they are designated as safety-of-life services by their status as both radionavigation-satellite service ("RNSS") and aeronautical radionavigation satellite service ("ARNS") bands, and thus require special consideration under the international radio regulations.[9]

Over the years, GPS has become a major military and civilian "utility" worldwide, relied on by applications requiring precise location and time synchronization of information. Many of the applications have strong safety of life requirements. GPS is core to the mobile information battlefield, including the operational theater, peace-keeping operations and humanitarian deployments. GPS has proven beneficial in such fields as transportation (space, land, sea, and air), surveying, mining, agriculture, banking, telecommunications, emergency response, and search and rescue operations, and has revolutionized or improved the efficiency of entire industries. It is emerging as an important tool of mobile E-911 and the mobile internet.

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[8] The use of satellites clustered near each other results in poorer calculated results than the use of satellites widely separated from each other. This is known as precision dilution of precision or PDOP.

[9] *See* International Radio Regulation S4.10, which provides that "Member States recognize that the safety aspects of radionavigation and other safety services require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies."

The accuracy of GPS in commercial and civil applications is constantly improving. President Clinton recently announced the removal of selective availability ("SA") in order to increase the accuracy for public users of GPS.[10] This latest action in a long sequence demonstrates the U.S. government's commitment to advance international commercial acceptance of and reliance on GPS as a global technology standard for safety-of-life applications and telecommunications.[11] Further, plans are already under way to modernize GPS and provide improved capabilities sought by military and civilian users of this information utility. These improvements will further enhance GPS accuracy.[12]

GPS satellites transmit a very low power, data-only signal (on the order of 50 bps). The basic GPS architecture of space and ground segments has been unchanged since its conception in 1973, and there is no ability for the GPS user segment to accommodate any interference above the level at which the system was designed to operate. In particular, the amount of available power in space is fixed at any particular time and increasing on-board power to satellites orbiting at 10,900 nautical miles is a costly, lengthy process that takes many years. This is a fundamental constraint on the placement of in-band, out-of-band, or any other unwanted emissions into frequency bands where the GPS system operates.

GPS has become an integral part of the United States and world economic infrastructure. GPS is used in many commercial applications where continued availability of uninterrupted timing signals and position information is critical to the underlying operation. For example, the world's rapidly growing financial, telecommunications, in-vehicle navigation, and e-commerce and Internet industries have become highly reliant on GPS for network synchronization. The following list of

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10 *See GPS Leader Magellan Corporation Applauds Government's End of Selective Availability; More Accurate GPS Signals Increase GPS Products' Usefulness and Safety Benefits*, PR Newswire, May 2, 2000 ("Selective Availability News Article").

11 *See GPS Now Even Better Choice for Network Sync with Recent U.S. Decision to Improve Accuracy of GPS Signals*, Business Wire, May 17, 2000; Selective Availability News Article.

12 *See Air Force Successfully Launches Global Positioning System Satellite Built by Lockheed Martin*, Business Wire, May 11, 2000. *See also* http://www.laaft.af.mil/SMC/CZ/homepage/.

representative GPS applications was presented in the report of the Radiocommunication Sector of the International Telecommunication Union ("ITU") to the 2000 World Radiocommunication Conference:[13]

[13] *See* Report of Conference Preparatory Meeting to 2000 World Radiocommunication Conference at Section 2.2.1.2.1 (page 12) (November 1999), *reproduced in* Document WRC-2000/03 (January 21, 2000). "RNSS" is the radionavigation-satellite service, the radiocommunication service within which the GPS satellites operate.

Examples of uses of RNSS

AGRICULTURE and FORESTRY
Forest area and timber estimates.
Identifying species habitats.
Fire perimeters.
Water resources.
Locating property boundaries.
Ploughing, planting and fertilizing without operators.

AVIATION
Oceanic and en route navigation.
Non-precision and precision all-weather approaches.
Direct routing of aircraft for fuel savings.
Improved aircraft separation standards for more efficient air traffic management.
Airport surface traffic management.
Monitor wing deflections in flight.
Wind shear detection.
Precise airfield and landing aid locations.
Seamless (global) air space management.
Less expensive avionics equipment.
Monitoring aircraft locations in flight.
Precision departures.
Missed approach applications
Enhanced ground proximity warning system.
Automatic dependent surveillance.

ELECTRIC POWER
Synchronization of power levels.
Event location.

EMERGENCY RESPONSE
Ambulance, police, and fire department dispatch.
Road service locating disabled vehicles.

ENVIRONMENTAL PROTECTION
Hazardous waste site investigation.
Ground mapping of ecosystems.
Oil spill tracking and cleanup.
Precise location of stored hazardous materials.

HIGHWAY and CONSTRUCTION
Intelligent vehicle-highway system operation.
Highway facility inventory and maintenance.
Accident location studies.
Highway construction.
Navigation for motor vehicle drivers.
Truck fleet on-the-road management.
Monitoring status of bridges.

LAW ENFORCEMENT and LEGAL SERVICES
Tracking and recovering stolen vehicles.
Tracking narcotics and contraband movements.
Maintaining security of high government officials and dignitaries while travelling.
Border surveillance.
Measuring and recording property boundaries.
Tort claim evidence in aviation and maritime accidents.

MARITIME and WATERWAYS
Navigation on the high seas.
Search and rescue.
All weather harbour approach navigation.
Vessel traffic services.
Dredging of harbours and waterways.
Positioning of buoys and marine navigation aids.
Navigation for recreational vessels.
Location of commercial fishing traps and gear.
Offshore drilling research.
Monitoring deflections in dams as a result of hydrostatic and thermal stress changes.
Ice breaking and monitoring icebergs and flows.
Observing tides and currents.
Harbour facility management.
Location of containers in marine terminals.

PUBLIC TRANSPORTATION
Bus fleet on-the-road management.
Passenger and operator security monitoring.

RAILROAD
Railroad fleet monitoring.
Train control and collision avoidance.
Facility inventory control and management.

RECREATION
Hiking and mountain climbing.
Measuring at sports events.
Setting lines on sports fields.

SURVEYING
Electronic bench marker providing absolute reference of latitude, longitude and altitude.
High precision surveys in minutes by anyone.
Real-time dam deformation monitoring.
Hydrographic surveying.
Efficient and accurate photo surveys.
Measuring areas without triangulation.
Oil and mineral prospecting.
National spatial data infrastructure.

TELECOMMUNICATIONS
Precise timing for interlacing messages/network synchronization.

WEATHER, SCIENTIFIC and SPACE
Use as weather balloon position radiosonde.
Measurement of sea level from satellites.
Navigating and controlling space shuttles.
Placing satellites into orbit.
Monitoring earthquakes and tectonic plates.
Measuring ground subsidence (sinking).
Measuring atmospheric humidity from ground.
Precise global mapping of ionosphere.

GPS, in its ever-expanding list of applications, has had a profound impact on the U.S. economy that cuts across all economic sectors. One recent study reported that the direct U.S. revenues of the global positioning market exceeded two billion dollars, and this direct impact on the U.S. economy is projected to more than double within the next six years.[14] The numbers increase exponentially when the ripple effect of improved efficiency on entire industrial sectors and direct and indirect international revenues are factored in.[15]

C. Protection Of The Integrity Of The GPS System Is A Fundamental Element Of U.S. National Policy.

The Council observes that both the U.S. Executive Branch and the Legislative Branch have made unequivocal and strong commitments to the continuous availability and protection of GPS. The Executive Branch has approved a comprehensive national policy to ensure the continued availability of GPS for "a broad range of military, civil, commercial, and scientific interests, both national and international,"[16] and views GPS as a global information utility.[17]

Congress has enacted very specific legislation requesting the Department of Defense to set a national strategy to "protect the integrity of the Global Positioning System frequency spectrum against interference and disruption," to "achieve full and effective" use of the GPS radio frequency spectrum, and to ensure "GPS evolution."[18] Congress has also requested the Executive Branch to

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14 *See GPS Products Gaining Acceptance Among Users In Untapped Markets, According to Study*, Space Business News, at 4-5, July 5, 2000 (citing study entitled *North American Global Positioning System Markets* by Frost & Sullivan research firm) ("Space Bus. News Article").

15 The signals transmitted by the non-geostationary satellites of the GPS system are available globally.

16 The White House, Office of Science and Technology Policy, National Security Council, Fact Sheet: U.S. Global Positioning System Policy, at 1-3 (released March 29, 1996) (Reference: Presidential Decision Directive NSTC-6).

17 *See* The White House, Office of the Vice President, Vice President Gore Announces New Global Positioning System Modernization Initiative, Initiative Would Make Global Positioning System More Accessible to Civilian Users, at 1 (released January 25, 1999).

18 Department of Defense Appropriation Act, Pub. L. No. 105-262, § 8137, 112 Stat. 2337 (1999) ("PL 105-262"). *See also* National Defense Authorization Act, Pub. L. No. 105-85, § 2281, 111 Stat. 1910 (1997) ("PL 105-85").

provide adequate resources to the Commerce Department to support international negotiations leading to the protection of the GPS spectrum from disruption and interference.[19]

Congress has also mandated that "[t]he Secretary of Defense shall provide for the sustainment and operation of the GPS Standard Positioning Service for peaceful civil, commercial, and scientific uses on a continuous worldwide basis."[20] Further, GPS is viewed as making "significant contributions to the attainment of national security and foreign policy goals of the United States, the safety and efficiency of international transportation, and the economic growth, trade and productivity of the United States."[21] For these reasons, Congress has expressed a clear national interest in protecting the GPS and its spectrum in order to prevent disruption and interference of GPS signals.[22]

On behalf of its members, many of whom are engaged in activities with safety-of-life applications, the Council is concerned that the operation of UWB systems in bands that overlap with or are near the GPS frequency bands would cause destructive interference to the millions of current GPS users in terrestrial, maritime, commercial and general aviation, and space safety-of-life applications. Any increase in the basic noise floor will significantly reduce the ability of the receiver to acquire or maintain tracking of a GPS signal, or will cause errors in position or time accuracy. Either of these consequences is unacceptable, and inconsistent with U.S. law and Presidential policy.

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19 *See* Commercial Space Act of 1998, Pub. L. 105-303, § 104(b), 112 Stat. 2852 (1998).

20 PL 105-85, § 2281(b).

21 *Id.* at § 1074(a)(1).

22 *See id.* at § 1074(a)(5). Congress is so concerned about any restrictions placed on GPS that it goes so far as to give the Department of Defense veto power over a decision of any other department or agency that would adversely affect the military potential of the GPS. *See id.*, PL 105-85, § 2281(b)(5).

D. The Commission Has Appropriately Recognized The "Vitally Important" Need To Protect GPS And Other Services Operating In Restricted/Safety Bands From UWB Interference.

In the *NPRM*, the Commission states that "it is vitally important that critical safety systems operating in the restricted frequency bands, including GPS operations, are protected against interference."[23] With specific reference to GPS, the Commission stated that it was particularly concerned about the impact of any potential interference to GPS in the "L1" band at 1559-1610 MHz and in the "L5" band that was established in the 1164-1215 MHz band at the 2000 World Radiocommunication Conference subsequent to the release of the *NPRM*.[24]

The Commission's concern about the impact to GPS from UWB transmissions extends, quite correctly, well beyond the uses of GPS in aviation applications. The Commission expressly noted that:

> GPS may be used by commercial mobile radio E-911 services to enable police and fire departments to quickly locate individuals in times of emergency. Moreover, use of GPS is expanding for use by businesses and consumers for all sorts of applications, such as for navigation by automobiles, boats and other vehicles, surveying, hiking, and geologic measurements. Therefore, any harmful interference to GPS could have a serious detrimental impact on public safety, businesses and consumers.[25]

Based on the latest data, there are nearly twenty million direct users of GPS around the world today. Between the many safety, commercial, and consumer applications of GPS, the number of indirect beneficiaries of the continued reliable operation of GPS – from airline passengers to stock market investors to users of resources that are produced more efficiently as a

[23] *See NPRM*, FCC 00-163, slip op. at 11 (¶ 24).

[24] *See id.* at 13 (¶ 28).

[25] *Id.* (emphasis added).

result of GPS technology – is well into the hundreds of millions.[26] The Council cannot agree more that GPS in all of its applications – whether land, aeronautical or marine, and whether civil, commercial, consumer or military – must be fully protected from the detrimental effects that could be produced by UWB transmissions.

E. Overview Of Comments

The Council accepts the Commission's tentative determination that UWB devices may hold out the promise of significant benefits for public safety, businesses, and consumers.[27] The Council recognizes that applications of UWB technology, which as noted above date back to the earliest days of radio transmissions, have a long history of military control in a closed systems environment. The military use centered on clandestine radio and radar, neither of which required a particularly efficient use of the frequency spectrum in operational deployment. Unlike GPS, where dual-use utility operation was designed into the system from the beginning, commercialization of UWB represents a force fitting of formerly military technology into an open information technology environment. The rapidly evolving civilian National Information Infrastructure environment is neither a closed system nor is it tolerant of an inefficient use of the frequency spectrum. Inefficient frequency use equates to lower effective data rates in any given frequency band. At this point in time, however, civil and commercial applications of UWB technology are completely unproven from either a technical or a market standpoint – a fact that stands in stark contrast with the status of

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26 Much of the use of GPS includes safety-of-life applications. In aviation, GPS is used for transoceanic and en route navigation, aids to landing, and for wind shear detection. In maritime environments, GPS is used for navigation on the high seas, search and rescue, positioning of buoys and marine navigation aids, docking of high-speed ferries, and precision coastal and harbor approach operations. In the differential beacon augmentation systems, GPS is used for increased accuracy in the coastal confluence zones of many nations around the world, and in surface transportation, they are used in such critical applications as monitoring of bridge status and train control, collision avoidance, and the transportation of hazardous materials. Also, GPS is an enabling technology for the nation's emerging Intelligent Transportation Systems ("ITS") infrastructure. Federal, state, and local governments are increasingly relying on GPS for use in ambulance, police and fire department dispatch, and to provide disaster management and relief for hurricanes, floods, earthquakes, and fires.

27 *See NPRM*, FCC 00-163, slip op. at 4 (¶ 7).

many of the services and applications (from broadcast television, to broadband internet access, to GPS) that would suffer harmful interference as a result of UWB transmissions. Attachment A to these Comments contains a more detailed discussion of technical issues involved in assessing interference produced by UWB devices.

Much of the confusion arising from the Commission's *NPRM* and the underlying proposals for introduction of UWB applications is attributable to the challenges posed by the nature of UWB itself. First of all, UWB is a technology, not a "service." In the past, it would have been expected that an applicant would apply to the Commission for authority to provide a radiocommunication service that uses UWB technology or to request Commission authorization to employ the technology in a device that would otherwise be unregulated; an applicant would not apply to provide "UWB service." In other words, "UWB" is a shorthand classification for a wide and as yet ill-defined class of emitters that is usually characterized by short, high-energy pulses that use wide swaths of spectrum and cut across many allocated services.[28] Some applications of UWB – *e.g.*, the types of communications applications that are contemplated by at least one of the holders of the waivers of Part 15 requirements that were issued last year – would appear to be radiocommunication services that would require independent Commission service rules (under a new set of regulations). Other applications of UWB technology, such as ground-penetrating radars ("GPR") or through-the-wall imaging devices ("WID"), appear to fall within a different category of emitters, which may be appropriate for operation under a new set of regulations.

The Council calls upon the Commission, as the latter moves forward with the instant proceeding, to come to grips first with the fact that UWB proponents are harkening back to the pre-regulatory era of purely time-domain radio use, and then to determine whether (and if so, to what extent) such a uses are compatible with the irretrievably entrenched frequency domain regime that

[28] *See* Attachment A, Technical Appendix.

provides the longstanding foundation for the Commission's and the world's radiofrequency spectrum management policy.[29] In some respects, the Commission's *NPRM* seeks to accomplish this on an ad hoc basis when it proposes to exclude all but those few types of UWB devices with extremely low interference potentials from operation in frequency bands below about 2 GHz.[30] A more comprehensive and systematic approach to these difficult questions is required, as is a complete understanding of the physical science underlying UWB technology. The Council believes that once such an approach is undertaken and a better understanding is gained, many of the individual elements the Commission and commenters are struggling with will fall into line.

As it addresses the structural questions raised by UWB, and moves away from the difficulties associated with the attempt to pigeonhole the time-domain-based UWB technology issues into the frequency-domain-based regulatory scheme under which it operates, the Commission should focus in on a pair of core characteristics of UWB – one that is technical and one that is regulatory. On the technical side, UWB interference cannot readily be characterized by frequency domain measurements, because the waveform-to-waveform variability is so high. Consequently, UWB devices will need to be licensed on a waveform-by-waveform basis. It is clear from initial measurement testing that the pulse repetition frequency ("PRF") of the UWB device, in combination with the duty cycle of the UWB interfering signal, has one major effect.[31]

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29 As they are in the U.S., the oversight and spectrum stewardship functions performed by the Radiocommunication Sector of the International Telecommunication Union are based on a frequency domain. *See* Article S5 of the International Radio Regulations. The only possible exception to this reality, at least internationally, is within the frequency range from about 275 GHz to 400 GHz, where no frequency allocations have been made.

30 *See NPRM*, FCC 00-163, slip op. at 14 (¶ 30).

31 If the UWB pulse repetition frequency (PRF) is below 200,000 pulses per second (pps), then it will have a much smaller impact on GPS than signals with higher PRFs. In general, the PRF needs to be a small fraction of the bandwidth of the filters in the front end of the GPS receiver. If the PRF is relatively low, then the pulses will still be distinct at the output of the filter and the receiver will simply lose the benefit of the GPS signal during the on-time of the filtered pulse. If the PRF is high, then the pulses will be smeared by the filter and the receiver will be confronted with an essentially constant or continuous interference. In this latter case, the receiver will be unable to recover any GPS signal unless the interfering signal is very weak. GPS receivers have bandwidths as low as 2 MHz and the duty cycle of the interfering signal, after filtering, must be smaller than 10%. Consequently, UWB prfs of 100,000 to 200,000 pps will probably have a much smaller effect on GPS than higher PRFs.

On the regulatory side, confusion results because of the assumption that very diverse applications can be addressed through existing or appropriately modified Commission regulations. The application of UWB technology having the characteristics of networked radiocommunication services requires independent evaluation and consideration of factors that are beyond the scope of the instant proceeding. It is the consumer nature of this application that is driving the strident requests for unlicensed regulatory status. The GPR and WID applications of UWB are directed at public safety markets, including police and fire. These public safety markets currently license their communication radios; therefore, licensing UWB for these uses should pose no substantive marketing burden. However, the communications device class of UWB emitters, along with the open-air UWB radar class (e.g., collision avoidance radars) appear to be inappropriate for the types of general provisions the Commission is contemplating in the *NPRM,* as these emitters raise independent policy and public interest questions.

Both sets of inquiries are critical to the successful resolution of this proceeding. If they are resolved properly, the Commission should be able to establish rules that will enable at least some applications of UWB technology to be implemented in the near future, while providing the necessary protection to GPS receivers and other services in the restricted bands.

The Council maintains that in the absence of the full understanding of the interference implications, it would be unwise for the Commission to consider allowing UWB devices to operate in the restricted GPS bands. The wide variety of potential UWB applications and the tricky nature of testing emitters that operate in the time domain combine to preclude the Commission from making any generalizations from preliminary test results derived from UWB radar emitters. Instead, these factors dictate that rules adopted in this proceeding must be very precise as to the types of specific UWB waveforms and their applications that may be permitted and the conditions under which those emitters will operate. Given the early historical experience with UWB, there still is no known way to ensure the coexistence of time domain devices and frequency domain devices without regressing to the earlier state of cacophony. However, it is understood that the frequency spectrum is an international resource to be developed carefully and efficiently. It is critical to preserve the economic dynamism of the NII and to promote innovation while providing a stable environment for public and private investment decisions. The Commission cannot allow specific firms and potential individual applications alone to determine the technological approach that UWB will take, but, to protect the thriving NII marketplace, must instead set forth a specific and stringent regulatory regime that protects the public interest.

At this point, and in advance of the receipt of any results of even the limited ongoing measurements of interference to be caused by UWB radars to GPS receivers, the Council is hopeful that ongoing experiments will show that ground-penetrating radars and through-the-wall imaging devices employing UWB technology will, if subjected to proper regulatory and operational conditions, be able to operate in some part of the radiofrequency spectrum in a manner that is compatible with GPS. The Council is not now in a position to prejudge whether such devices – which expressly do not include so-called collision avoidance radars that operate in free space – would be able to use restricted bands in which GPS and other safety services operate, or would have to be relegated to higher bands (e.g., bands above 3.0 GHz, as described in Section III.2.a, *infra*). Once reliable test results are in and analyzed, the Council will be in a position to comment on the frequency bands that are acceptable for operation of small numbers of licensed GPRs and WIDs for public safety use, and whether devices in this subset of the UWB radar category are appropriate for regulation under existing Commission rules (outside of Part 15) or whether they instead trigger such regulatory concerns as to require creation of an entirely new Part of the Commission's rules to reflect their unique technical characteristics.

It is abundantly clear, however, that simply characterizing UWB devices using such frequency domain measurement characteristics as, but not limited to, PRFs, is not sufficient. The Commission must consider the specific UWB waveform to be used in the specific application. Networked applications of UWB devices provide significantly more difficult regulatory challenges, as do UWB radars that are not operated at all times in direct contact with the ground or a wall. Such UWB devices and scenarios must not be permitted at frequencies overlapping or near GPS frequencies. If the basic science, regulatory and operational issues can be resolved, it may be possible to develop rules that allow such UWB operations in bands above 3.0 GHz[32] – provided that strict limits on unwanted emissions into the GPS bands are imposed.

The Commission has asked a series of specific technical questions in the *NPRM.* These are important questions, and many of them cannot be answered adequately prior to the establishment of the basic scientific framework for the comprehensive testing program and for the regulatory environment once the tests and analyses are completed and reconciled. The Council cautions the Commission not to rush to hasty judgment on these important questions and to refrain from drawing broad conclusions on the limited data that it will receive from tests involving just two UWB radar devices.[33]

A single data set from a single UWB application involving a single type of UWB waveform is not sufficient to bring to light all the unknowns regarding UWB applications in advance of the date by which the Commission intends to adopt final rules. As shown below, there is significant disagreement regarding the adequacy of the various approaches to testing and measurement. The

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[32] Although the Commission proposed a cut-off at 2.0 GHz for all UWB devices other than certain GPRs and WIDs, the Council observes that it may be appropriate to consider a preclusion of such UWB devices in bands below about 3 GHz, as there are restricted and safety bands between 2 and 3 GHz, not just below 2 GHz. *See* 47 C.F.R. § 15.205(a). Thus, the Council includes the 3.0 GHz cut-off point in its Comments, rather than the 2.0 GHz point proposed in the *NPRM.*

[33] The Commission has asked for test results by October 30, 2000 and suggests that it will quickly move to establish rules after only limited time for public comment. *See NPRM*, FCC 00-163 slip op. at 1 (¶ 1), 14 (¶ 31).

Council believes that more time is necessary to establish the physical science framework for measurement testing and to find the appropriate ways to manage the coexistence of fundamentally different sets of devices. Until testing is complete, the more prudent approach is to use known band segmentation techniques.

Accordingly, it is premature to develop rules of general applicability in the instant proceeding. It could be that a particular UWB application could be developed as a networked communications service, but the Commission does not yet have any information on the characteristics of such a service, and therefore lacks any basis to make judgments on related interference issues. For these reasons, the Commission should not seek to set ground rules for applications or services below 3 GHz as a result of this initial *NPRM.* The Commission must proceed carefully to make informed decisions, and should issue follow-up notices of proposed rulemaking or notices of inquiry, as appropriate, concerning such potential services once the underlying physical science framework has been established and it has had an opportunity to evaluate some operational history with commercial UWB devices operating in its segmented band.

The Council recommends that the Commission obtain comprehensive and rigorous test results for radars and analyze and reconcile those results prior to establishment of provisional or permanent rules for any UWB devices in their own band segment, including appropriately conditioned GPRs and WIDs. Beyond establishing ground rules for these devices, the FCC should limit the initial stage of this proceeding to establishing a regulatory framework to be used to set new rules for UWB services on a case-by-case basis in their own band.

III. DISCUSSION

A. The Commission Should Adopt A Two-Pronged Initial Approach To UWB That Takes Into Account The Fact That UWB Technology Supports Multiple Potential Services And Applications With Varying Interference Impacts On Existing Victim Services.

The concept of UWB is difficult to pigeonhole from a regulatory standpoint, and the Commission should be careful not to generalize too much on the basis of the few examples of UWB applications that have emerged to date. In the *NPRM* the Commission is seeking the definition of UWB, but the fact is that there are different categories of UWB systems or services that have emerged or that are envisioned. For example, the Commission cites different classes of radar systems as well as communications applications.[34] All such devices or services have their own set of parameters and in fact produce different levels of interference[35] – characteristics that have not been determined as of this date and will not be defined even after October 30, which is the deadline the Commission established for submission of test results. It would be virtually impossible for the Commission to define all of the characteristics of myriad UWB devices and potential services in this proceeding in such a way as to be able to develop effective protection criteria for safety-of-life and other sensitive systems.

The Commission should use the current rulemaking proceeding principally for two purposes. First, the Commission should establish the regulatory framework within which specific applications of UWB technology will be considered in the future, perhaps in further notices of proposed rulemaking. And secondly, the Commission should use this proceeding to establish specific conditions for the introduction of a limited class of licensed UWB radar devices, the actual non-restricted operational bands for which will be determined on the basis of comprehensive and rigorous testing, and regulations necessary to protect public safety uses of GPS. Also to be

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[34] *Id.* at 5-6 (¶¶ 10-12).

[35] *Id.* at 6 (¶ 13).